WHAT IS CLAIMED IS

1. A method of producing a zinc oxide thin film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc ions, ammonium ions and zinc ammonia complex ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

2. A method of producing a zinc oxide thin film according to Claim 1, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

3. A method of producing a zinc oxide thin film according to Claim 1, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 8 to pH 12.5.

4. A method of producing a zinc oxide thin film according to Claim 1, wherein the hydrogen ion concentration of the aqueous solution near the uppermost surface in which the zinc oxide thin film is formed is controlled in the range of pH 6 to pH 8.

5. A method of producing a zinc oxide thin film according to Claim 1, wherein the aqueous solution contains a hydrocarbon.

6. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution containing at least zinc ions, ammonium ions and zinc ammonia complex ions by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and forming a semiconductor layer.

7. A method of producing a photovoltaic device according to Claim 6, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

8. A method of producing a photovoltaic device according to Claim 6, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 8 to pH 12.5.

9. A method of producing a photovoltaic device according to Claim 6, wherein the hydrogen ion concentration of the aqueous solution near the uppermost surface in which the zinc oxide thin film is formed is controlled in the range of pH 6 to pH 8.

10. A method of producing a photovoltaic device according to Claim 6, wherein the aqueous solution contains a hydrocarbon.

11. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc ions, ammonium ions and zinc ammonia complex ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

12. A method of producing a semiconductor device substrate according to Claim 11, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

13. A method of producing a semiconductor device substrate according to Claim 11, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 8 to pH 12.5.

14. A method of producing a semiconductor device substrate according to Claim 11, wherein the hydrogen ion concentration of the aqueous solution near the

uppermost surface in which the zinc oxide thin film is formed is controlled in the range of pH 6 to pH 8.

15. A method of producing a semiconductor device substrate according to Claim 11, wherein the aqueous solution contains a hydrocarbon.

16. A method of producing a zinc oxide thin film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc ions, hydrogenzincate ions and zincate ions, and an electrode as a cathode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

17. A method of producing a zinc oxide thin film according to Claim 16, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

18. A method of producing a zinc oxide thin film according to Claim 16, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 8 to pH 12.5.

19. A method of producing a zinc oxide thin film according to Claim 16, wherein the hydrogen ion concentration of the aqueous solution near the uppermost surface in which the zinc oxide thin film is formed is controlled in the range of pH 6 to pH 8.

20. A method of producing a zinc oxide thin film according to Claim 16, wherein the aqueous solution contains a hydrocarbon.

21. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution containing at least zinc ions, hydrogenzincate ions and zincate ions

by passing a current between the conductive substrate and an electrode as a cathode immersed in the aqueous solution; and

forming a semiconductor layer.

22. A method of producing a photovoltaic device according to Claim 21, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

23. A method of producing a photovoltaic device according to Claim 21, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 8 to pH 12.5.

24. A method of producing a photovoltaic device according to Claim 21, wherein the hydrogen ion concentration of the aqueous solution near the uppermost surface in which the zinc oxide thin film is formed is controlled in the range of pH 6 to pH 8.

25. A method of producing a photovoltaic device according to Claim 21, wherein the aqueous solution contains a hydrocarbon.

26. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc ions, hydrogenzincate ions and zincate ions, and an electrode as a cathode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

27. A method of producing a semiconductor device substrate according to Claim 26, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

28. A method of producing a semiconductor device substrate according to Claim 26, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 8 to pH 12.5.

29. A method of producing a semiconductor device substrate according to Claim 26, wherein the hydrogen ion concentration of the aqueous solution near the uppermost surface in which the zinc oxide thin film is formed is controlled in the range of pH 6 to pH 8.

30. A method of producing a semiconductor device substrate according to Claim 26, wherein the aqueous solution contains a hydrocarbon.

31. A method of producing a zinc oxide thin film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least carboxylic acid ions and zinc ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

32. A method of producing a zinc oxide thin film according to Claim 31, wherein the aqueous solution is an aqueous solution of zinc acetate.

33. A method of producing a zinc oxide thin film according to Claim 31, wherein the aqueous solution is an aqueous solution of zinc formate.

34. A method of producing a zinc oxide thin film according to Claim 31, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

35. A method of producing a zinc oxide thin film according to Claim 31, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.

36. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution containing at least carboxylic acid ions and zinc ions by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and

forming a semiconductor layer.

37. A method of producing a photovoltaic device according to Claim 36, wherein the aqueous solution is an aqueous solution of zinc acetate.

38. A method of producing a photovoltaic device according to Claim 36, wherein the aqueous solution is an aqueous solution of zinc formate.

39. A method of producing a photovoltaic device according to Claim 36, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

40. A method of producing a photovoltaic device according to Claim 36, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.

41. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least carboxylic acid ions and zinc ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

42. A method of producing a semiconductor device substrate according to Claim 41, wherein the aqueous solution is an aqueous solution of zinc acetate.

43. A method of producing a semiconductor device substrate according to Claim 41, wherein the aqueous solution is an aqueous solution of zinc formate.

44. A method of producing a semiconductor device substrate according to Claim 41, wherein the conductive substrate comprises a support and a transparent conductive layer deposited thereon.

45. A method of producing a semiconductor device according to Claim 41, wherein the hydrogen ion concentration of the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.

46. A method of producing a zinc oxide film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc acetate, zinc ions and acetations, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

47. A method of producing a zinc oxide film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc formate, zinc ions and formate ions and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

48. A method of producing a zinc oxide film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc benzoate, zinc ions and benzoate ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

49. A method of producing a zinc oxide film comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least carboxylic acid ions and zinc ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate, wherein the aqueous solution is controlled in the range of pH 3.5 to pH to 5.5.

50. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution containing at least zinc acetate, zinc ions and acetate ions, by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and

forming a semiconductor layer on the top of the zinc oxide thin film.

51. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution containing at least zinc formate, zinc ions and formate ions, by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and

forming a semiconductor layer on the top of the zinc oxide thin film.

52. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution containing at least zinc benzoate, zinc ions and benzoate ions, by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and

forming a semiconductor layer on the top of the zinc oxide thin film.

53. A method of producing a photovoltaic device comprising the steps of:

forming a zinc oxide thin film on a conductive substrate immersed in an aqueous solution controlled in the range of pH 3.5 to pH 5.5 containing at least zinc benzoate, zinc ions and benzoate ions, by passing a current between the conductive substrate and an electrode as an anode immersed in the aqueous solution; and

forming a semiconductor layer on the top of the zinc oxide thin film.

54. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc acetate, zinc ions and acetate ions, and an electrode as an

anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

55. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc formate, zinc ions and formate ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

56. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least zinc benzoate, zinc ions and benzoate ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate.

57. A method of producing a semiconductor device substrate comprising passing a current between a conductive substrate immersed in an aqueous solution containing at least carboxylic acid ions and zinc ions, and an electrode as an anode immersed in the aqueous solution to form a zinc oxide thin film on the conductive substrate, wherein the aqueous solution is controlled in the range of pH 3.5 to pH 5.5.